Hanford System Overview

Aluminum and Chromium Leaching for HLW Sludge Workshop
Atlanta, GA

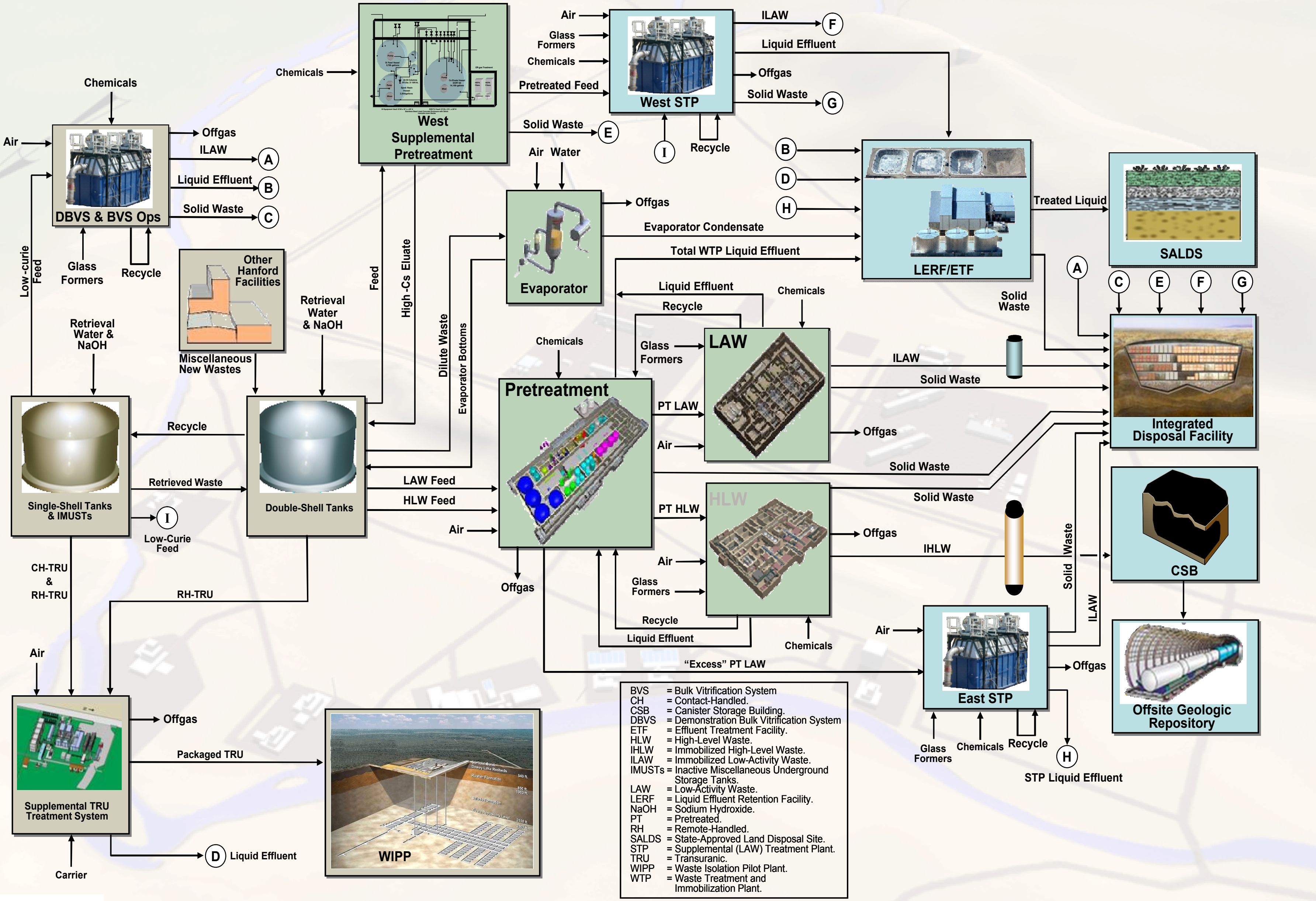
Paul Certa
Tom Crawford

January 23-24, 2007

CH2MHILL

CH2M-32399-VA

Hanford Tank Waste Treatment System



BVS = Bulk Vitrification System
CH = Contact-Handled.
CSB = Canister Storage Building.
DBVS = Demonstration Bulk Vitrification System
ETF = Effluent Treatment Facility.
HLW = High-Level Waste.
IHLW = Immobilized High-Level Waste.
ILAW = Immobilized Low-Activity Waste.
IMUSTs = Inactive Miscellaneous Underground Storage Tanks.
LAW = Low-Activity Waste.
LERF = Liquid Effluent Retention Facility.
NaOH = Sodium Hydroxide.
PT = Pretreated.
RH = Remote-Handled.
SALDS = State-Approved Land Disposal Site.
STP = Supplemental (LAW) Treatment Plant.
TRU = Transuranic.
WIPP = Waste Isolation Pilot Plant.
WTP = Waste Treatment and Immobilization Plant.

Hanford Sludge Washing, Leaching, and Oxidative Leaching Modeling

HNF-3157, Rev. 0

Best-Basis Wash and Leach Factor Analysis

PNNL-11646
UC-721

Pacific Northwest National Laboratory

Status Report:
Pretreatment Chemistry Evaluation
FY 1997—Wash and Leach Factors for the Single-shell Tank Waste Inventory

N. G. Colton

August 1997

Sludge Test Reports

Tanks	Wash / Leach	Oxidative Leach
SSTs	40	8
DSTs	4	2
Total	44	10

UPDATED TECHNETIUM-99 WASH FACTORS FOR HANFORD SITE TANK WASTES

Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator

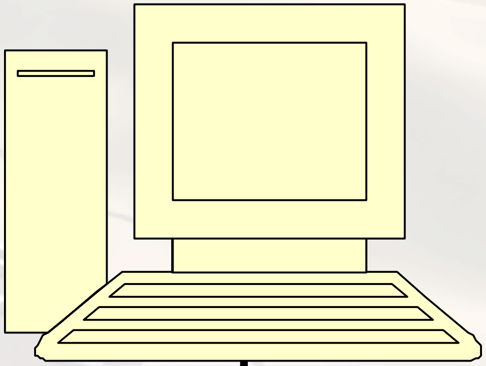
Chromium Wash and Leach Factors

Aluminum Wash and Leach Factors

Review of Phosphate and Sulfate Wash and Leach Factors

Modeling of Sludge Test Results

Hanford Tank Waste Operations Simulator (HTWOS) Modeling



SINGLE-SHELL TANK RETRIEVAL SELECTION AND SEQUENCE

Waste Retrieval Sequence

Hanford Tank Waste Operations Simulator Model Data Package for the Development Run for the Refined Target Case

Model Data Package

ORP-11242
Revision 2

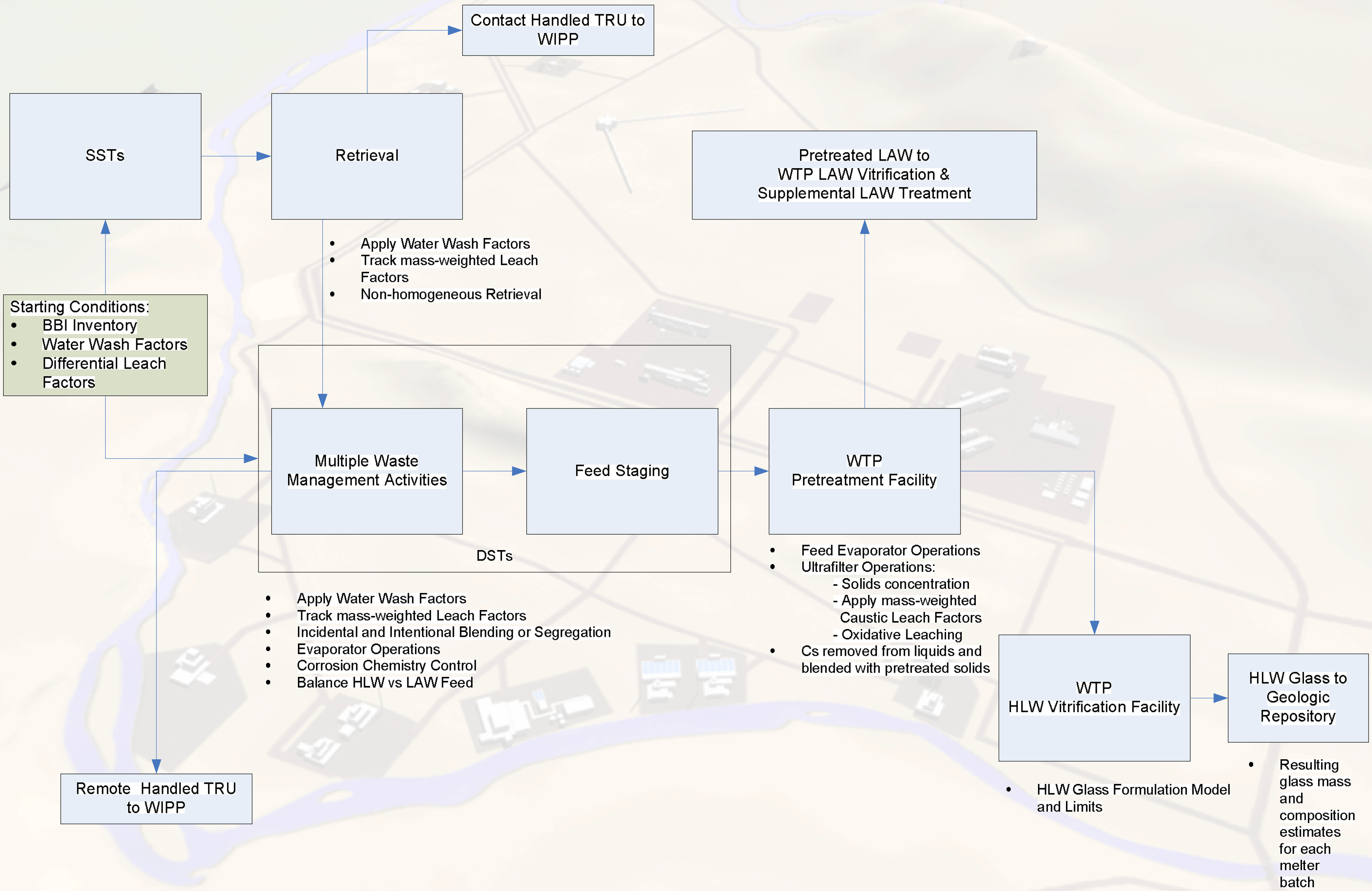
RIVER PROTECTION PROJECT SYSTEM PLAN

RETRIEVE AND TREAT HANFORD'S TANK WASTE AND CLOSE THE TANK FARMS TO PROTECT THE COLUMBIA RIVER

Model Results

CH2MHILL Hanford Group, Inc.

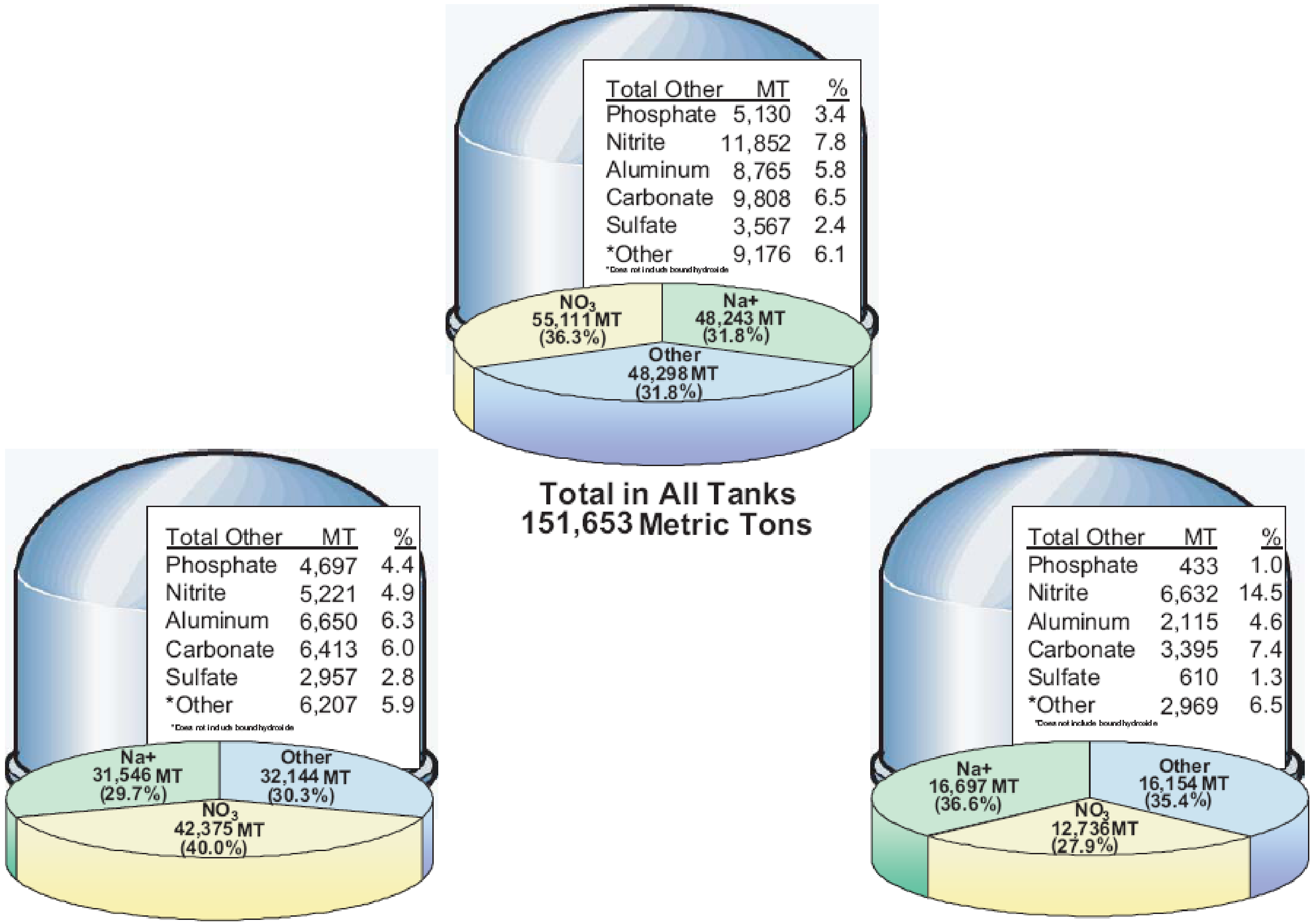
Conceptual Model – HLW Focus



Best-Basis Inventory

- The official database for SST and DST waste inventories
- Accessible through TWINS
- Integrates characterization data, process knowledge, and surveillance data to estimate tank inventories for 177 tanks, 25 chemicals, 46 radionuclides and supplemental analytes
- Presents volume, inventory, and concentration values by phase
  - Supernatant, Saltcake (solid and liquid), Sludge, Retained Gas
  - Sludge/Saltcake designation based on chemical composition of samples (if available) or by tank process history
- Projects uncertainty estimates for sample-based inventories
- Updated quarterly for transfers and new data
- All data evaluated for quality and representativeness
  - Core data may be subdivided if waste layers can be identified
- All updates go through rigorous review process

Hanford Tank Chemical Inventory



Total in All Tanks
151,653 Metric Tons

Total Other	MT	%
Phosphate	5,130	3.4
Nitrite	11,852	7.8
Aluminum	8,765	5.8
Carbonate	9,808	6.5
Sulfate	3,567	2.4
*Other	9,176	6.1

*Does not include bound hydroxide

Single-Shell Tanks
106,065 Metric Tons

Total Other	MT	%
Phosphate	4,697	4.4
Nitrite	5,221	4.9
Aluminum	6,650	6.3
Carbonate	6,413	6.0
Sulfate	2,957	2.8
*Other	6,207	5.9

*Does not include bound hydroxide

Double-Shell Tanks
45,587 Metric Tons

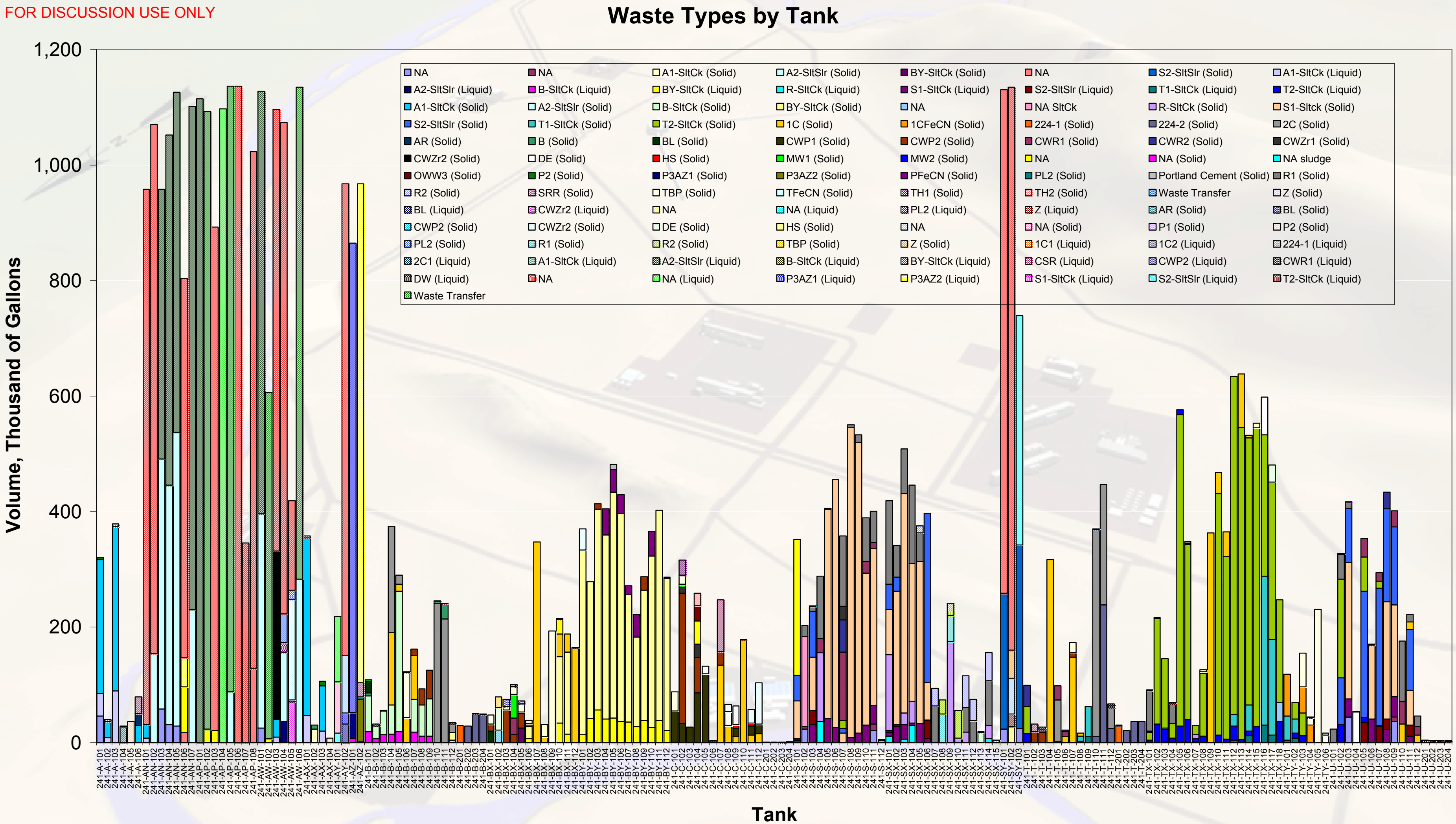
Total Other	MT	%
Phosphate	433	1.0
Nitrite	6,632	14.5
Aluminum	2,115	4.6
Carbonate	3,395	7.4
Sulfate	610	1.3
*Other	2,969	6.5

*Does not include bound hydroxide

Inventory updated through FY06 Q3, data downloaded from http://twins.pnl.gov Best Basis Summary query on 8/24/06

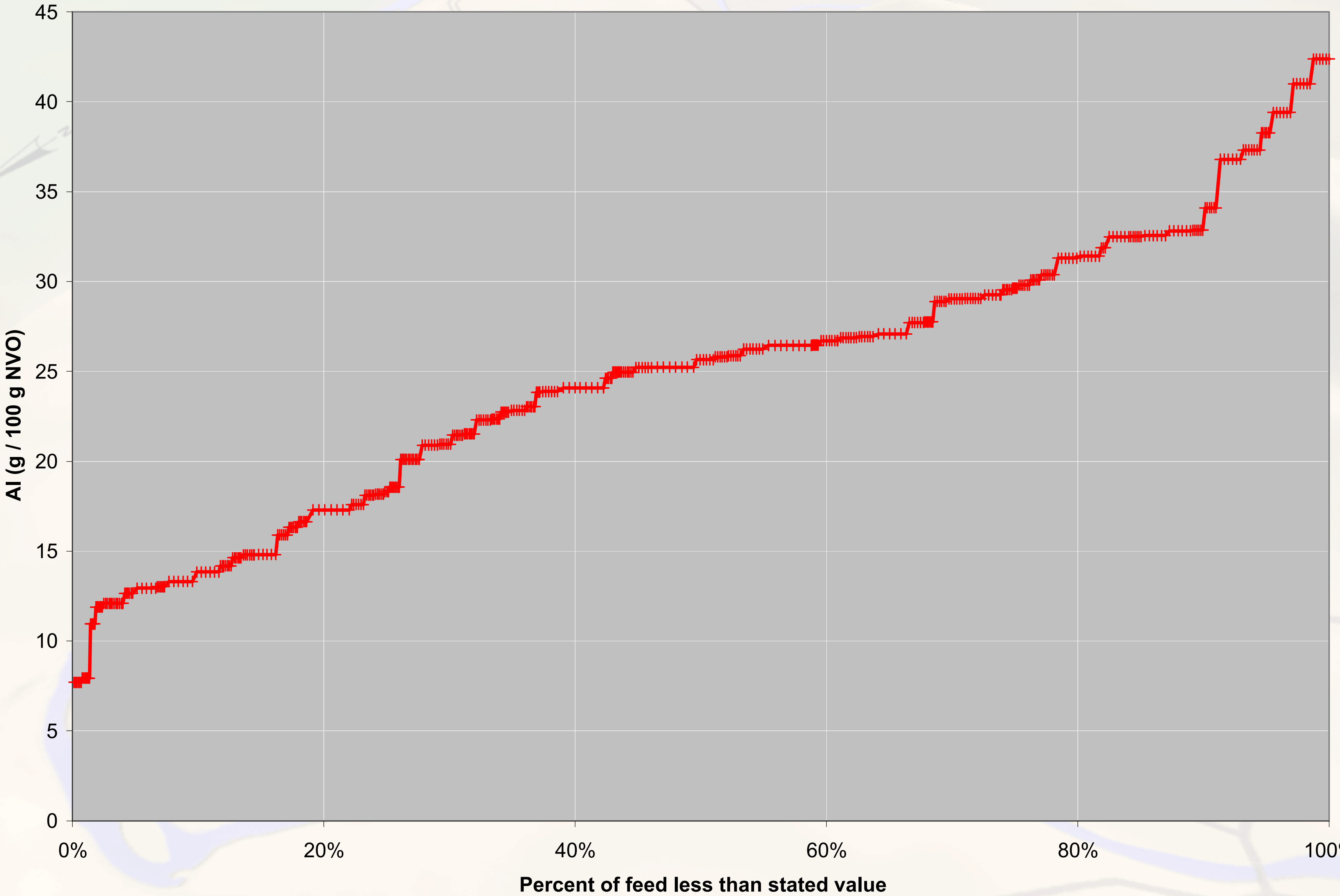
Waste Types by Tank

FOR DISCUSSION USE ONLY

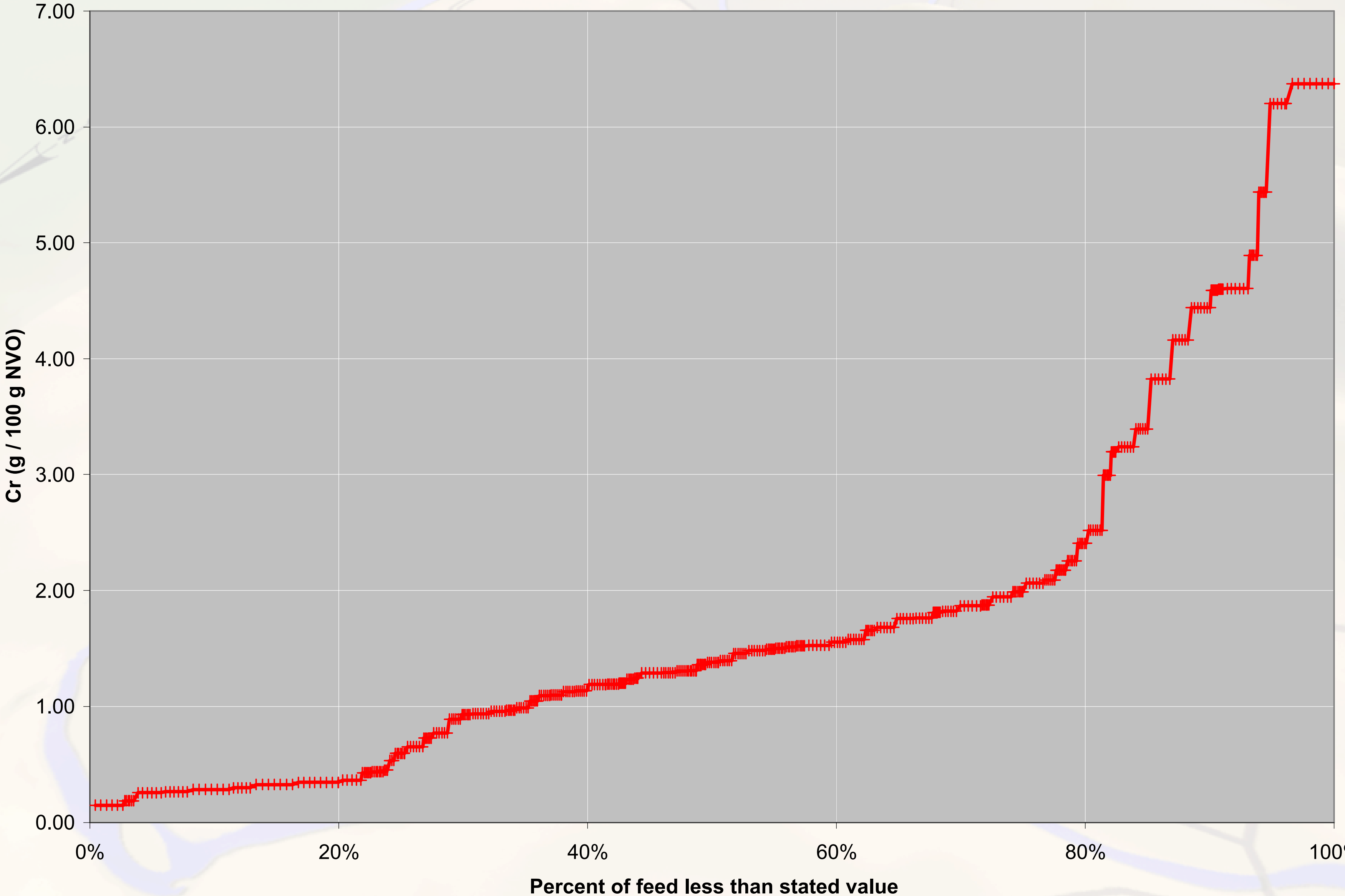


Tank waste is a complex mixture of multiple waste streams from various facilities, using flowsheets and feed stock that evolved over time.

Al in HLW Solids



Cr in HLW Solids



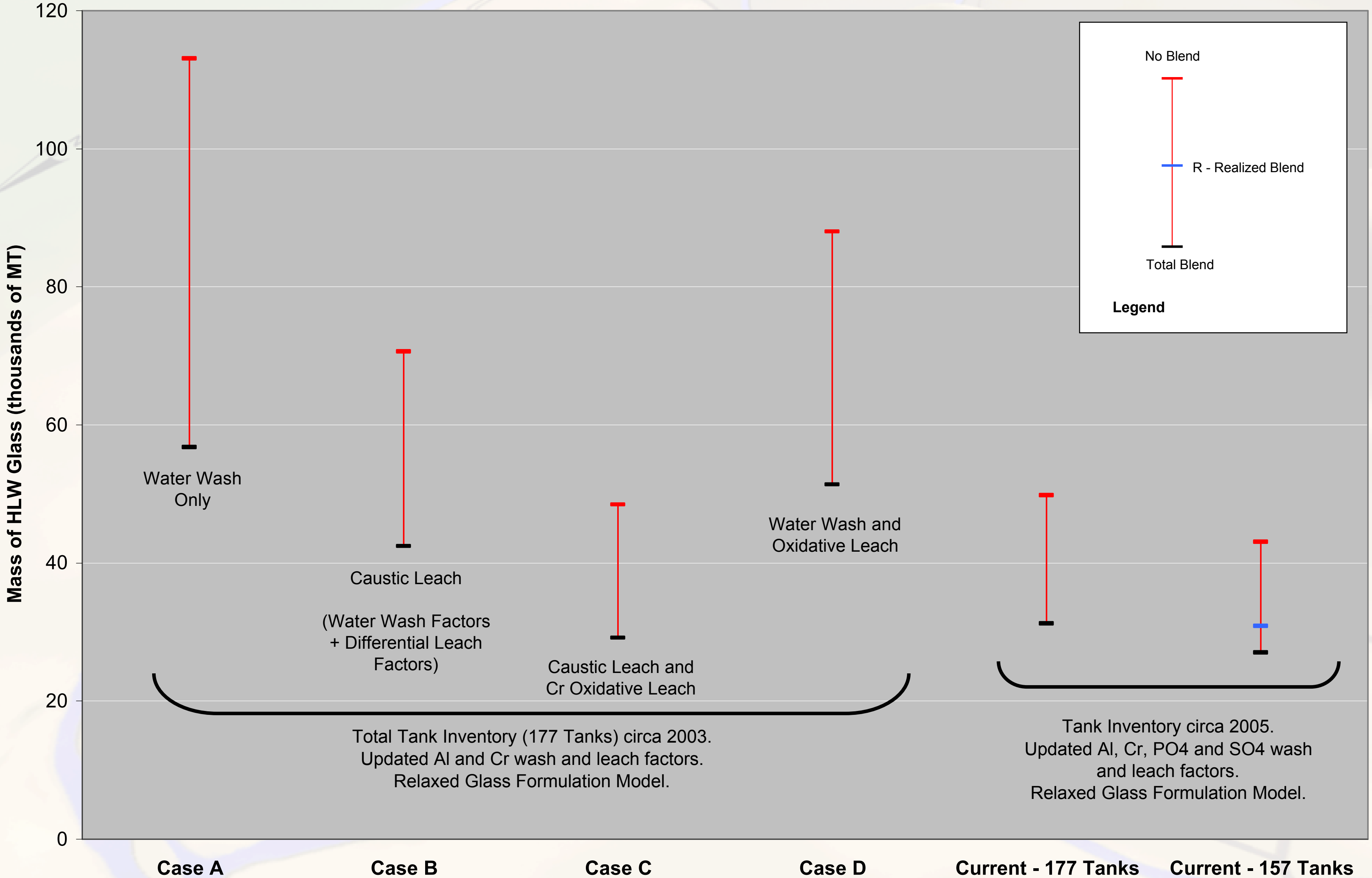
Factors Influencing the Delivered Feed Composition

- Waste Inventory
  - Starting Waste Inventory (BBI)
  - Waste sent to supplemental treatment or packaging
- Tank-specific retrieval process and technology
  - Water vs Supernate recycle
  - Caustic addition
  - Non-Homogeneous Retrieval
- Solid – Liquid Equilibrium
  - Water wash factors used to approximate SLE
  - Precipitation of solids (not in lifecycle model)
  - Evaporator operation
- Blending
  - Incidental
  - Intentional
  - Segregation

Wash and Leach Factor Limitations

- Zero-order approximation to complex solid-liquid equilibrium.
- Unidirectional
  - Does not predict precipitation
- Inconsistencies
  - Washed or leached anions and cations do not necessarily balance.
- Retrieval approaches confound the application of wash factors or differential leach factors
  - Non-homogeneous retrieval
  - Amount of water, recycled supernate and/or caustic used)

HLW Glass vs Degree of Pretreatment



Typical HLW Glass Drivers

- Taken from RPP-RPT-26040 Rev 0.
- Circa 2005 Tank Inventory.
- Excludes TRU tank waste and IMUSTs.
- Relaxed Glass Formulation Model.
- Updated Al, Cr, PO4 and SO4 wash and leach factors
- Oxidative leaching for Cr removal.
- Incidental blending of waste.

Table 8. Summary of Case 13 (Realized Blend Subcase) Glass Drivers.

Constraints[1]			Number of waste feed batches	Waste oxide mass[2] (MT)	Glass mass (MT)	Waste loading in glass[3]
Glass composition constraints	Solubility limited	SO_3	496	3,003	10,060	0.30
		P_2O_5	65	385	1,298	0.30
		Cr_2O_3	0	0	0	n/a
		Subtotal	561	3,388	11,358	0.30
	Model validity limited	Al_2O_3	338	2,110	6,946	0.30
		Fe_2O_3	52	331	980	0.34
		Na_2O	39	251	601	0.42
		SiO_2	0	0	0	n/a
		Subtotal	429	2,692	8,527	0.32
	Glass composition constraints subtotal		990	6,080	19,885	0.31
Glass property constraints	Spinel T_L involved		942	5,973	14,627	0.41
	Spinel T_L NOT involved		78	500	1,194	0.42
	Glass property constraints subtotal		1020	6,474	15,821	0.41
Case 13 Realized Blend subcase total			2010	12,553	35,706	0.35

Notes:
[1]Shaded cells indicate the major constraints that drive HLW glass mass.
[2]In this table, waste oxides refer to the fully pretreated waste on an oxide basis.
[3]Represents the weighted average waste loading in the glass from tanks that are limited by the same (or same group of) constraints. Units are mass fraction.
n/a = not applicable

Back Up Slides

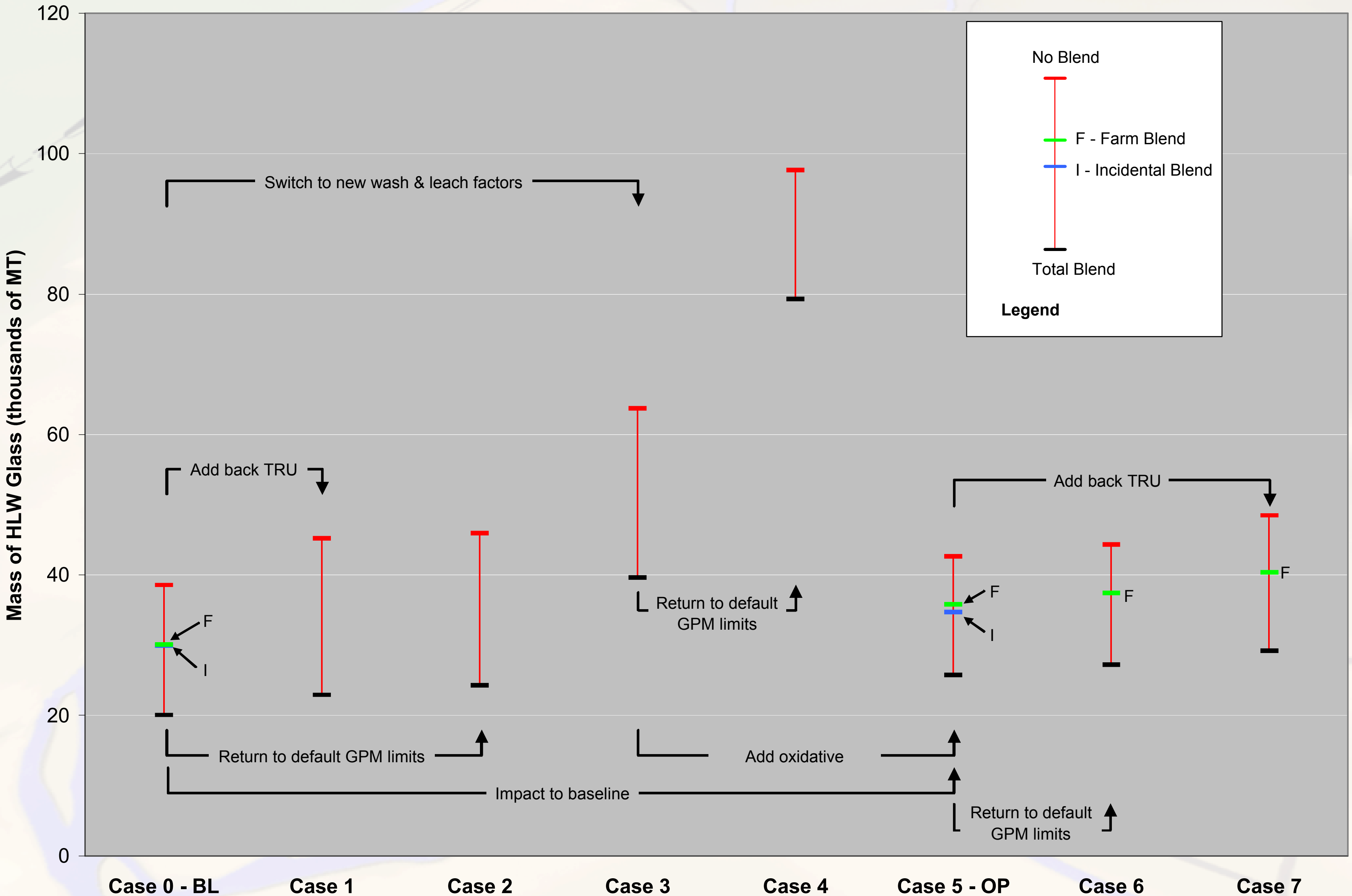
Key Wash and Leach Factor References

- **Recommend wash and leach factors**
  - HNF-3157, Rev 0A, 1999, *Best-Basis Wash and Leach Factor Analysis*
  - PNNL-11646, 1997, *Status Report: Pretreatment Chemistry Evaluation FY 1997 – Wash and Leach Factors for the Single-Shell Tank Waste Inventory*
  - RPP-10222, 2003, *Chromium Wash and Leach Factors*
  - RPP-11079, 2003, *Aluminum Wash and Leach Factors*
  - RPP-15552, 2003, *Hanford Waste Tank Oxidative Leach Behavior Analysis*
  - RPP-21807, 2004, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*
  - RPP-23329, 2005, *Updated Technetium-99 Wash Factors for Hanford Site Tank Wastes*
  - RPP-25903, 2005, *Review of Phosphate and Sulfate Wash and Leach Factors*
- **Sensitivity Studies**
  - RPP-20003, Rev. 1, 2005, *Sensitivity of Hanford IHLW Glass Mass to Chromium and Aluminum Partitioning Assumptions*
  - RPP-RPT-26040, 2006, *Pairwise Blending of High-Level Waste*, Appendix D.
- **Oversight**
  - D-03-Design-005, 2003, *Evaluation of Tank Waste Wash and Leach Factors*

Derivation of Best-Basis Inventory Estimates

- Estimates are based on sample data and process knowledge with preference given to sample data
- Sample Based Estimates
  - Calculated directly from tank samples
  - Provides most chemicals and some radionuclides
    - Core Samples
    - Auger Samples
    - Grab Samples
- Process Knowledge Based (Engineering) Estimates
  - Calculated from
    - Waste type templates,
    - Flowsheets,
    - Models and other process records.
  - The Hanford Defined Waste (HDW) model is the source of most radionuclide estimates
  - The HDW model is based on process flowsheets, tank farm records, and ORIGEN2 predictions

Sensitivity of HLW Glass Mass



HTWOS Model Summary

- Simulates Waste Treatment Mission
  - Flows and Mix Streams
  - Partition Streams (Evaporator, IX, S/L Separation, Wash & Leach, Splits or DFs)
  - Rule Based
  - Dynamic (time-varying compositions, discrete events
- Subject to Constraints
  - Tank Space
  - Production Rates
  - Transfer Rates
  - Equipment Availability
  - Simultaneous Transfers
  - Other Relevant Constraints
- Not Addressed
  - Reaction Kinetics
  - Thermodynamics (S/L Equilibrium)
  - Heat Transfer
  - Certain WTP Details
  - Reliability

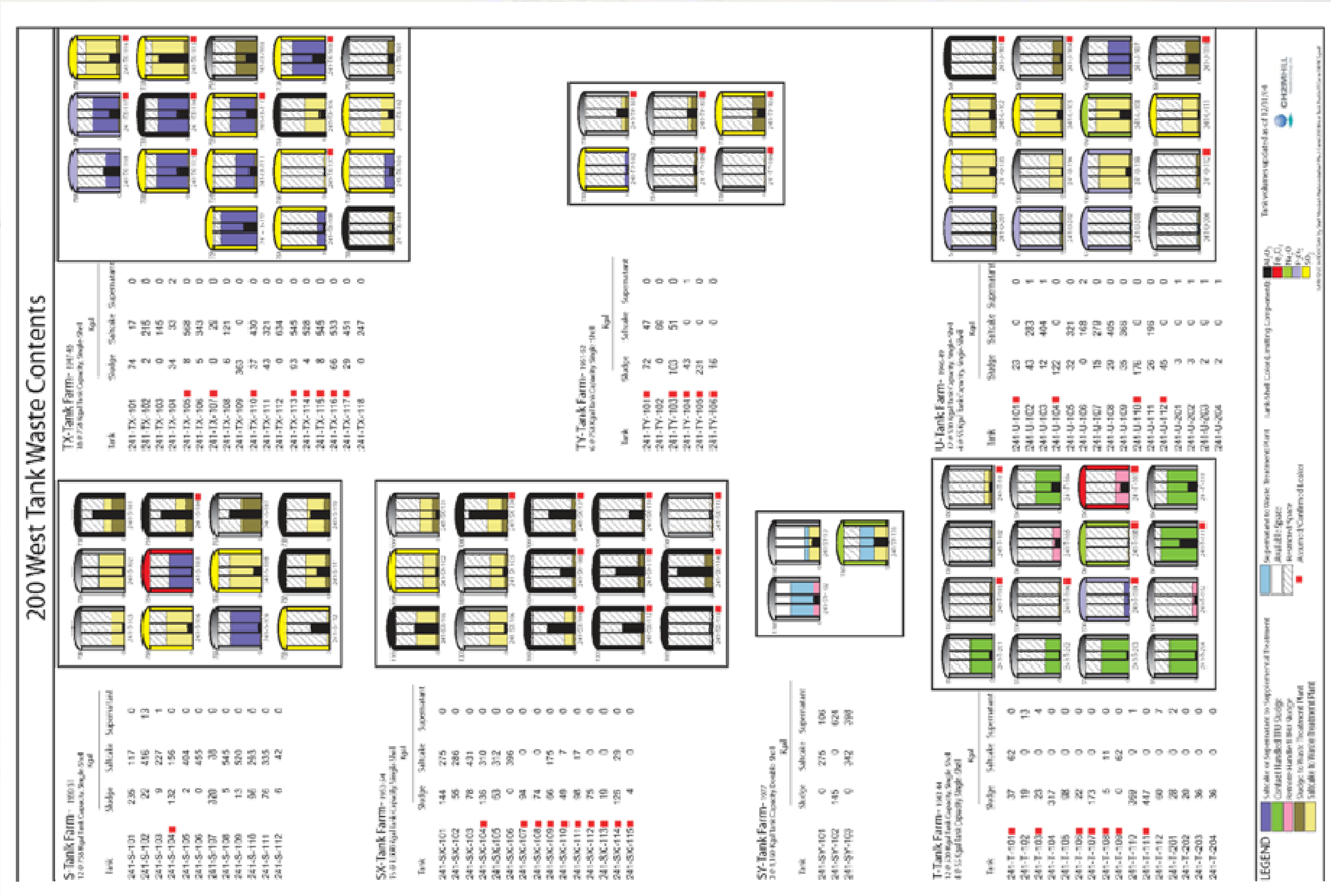
Typical HLW Glass Drivers

- Taken from RPP-RPT-26040 Rev 0.
- Circa 2005 Tank Inventory.
- Excludes TRU tank waste and IMUSTs.
- Relaxed Glass Formulation Model.
- Updated Al, Cr, PO4 and SO4 wash and leach factors
- Oxidative leaching for Cr removal.
- No Blending of tank waste.

Table D-3. Summary of Case 13 (No-Blend Subcase) Glass Drivers.

Constraints[1]			Number of waste feed batches	Waste oxide mass[2] (MT)	Glass mass (MT)	Waste loading in glass[3]
Glass composition constraints	Solubility limited	SO_3	41	2,107	11,701	0.18
		P_2O_5	16	710	3,779	0.19
		Cr_2O_3	3	177	318	0.56
		Subtotal	60	2,994	15,798	0.19
	Model validity limited	Al_2O_3	18	2,551	12,001	0.21
		Fe_2O_3	13	847	3,135	0.27
		Na_2O	6	629	2,313	0.27
		SiO_2	3	133	182	0.73
		Subtotal	40	4,160	17,631	0.24
	Glass composition constraints subtotal		100	7,154	33,429	0.21
Glass property constraints	Spinel T_L involved		45	3,156	8,747	0.36
	Spinel T_L NOT involved		6	339	935	0.36
	Glass property constraints subtotal		51	3,495	9,682	0.36
Case 13 No-Blend subcase total			151	10,649	43,111	0.25
Case 13 Total-Blend subcase total			--	10,641	27,080	0.39

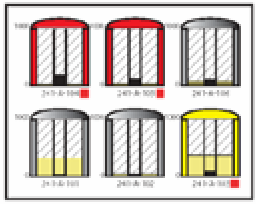
Notes:
[1]Shaded cells indicate the major constraints that drive HLW glass mass.
[2]In this table, waste oxides refer to the fully pretreated waste on an oxide basis.
[3]Represents the weighted average waste loading in the glass from tanks that are limited by the same (or same group of) constraints. Units are mass fraction.
n/a = not applicable


200 West Tank Waste Contents

200 East Tank Waste Contents

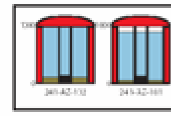
A-Tank Farm- 1954-55
6 @ 1,000 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-A-101	3	317	0
241-A-102	0	37	3
241-A-103 ■	2	364	4
241-A-104 ■	28	0	0
241-A-105 ■	37	0	0
241-A-106	50	20	0



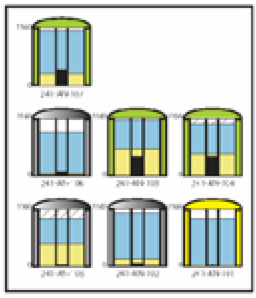
AZ-Tank Farm- 1975-76
2 @ 1,000 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AZ-101	52	0	849
241-AZ-102	105	0	878



AN-Tank Farm- 1981
7 @ 1,160 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AN-101	0	31	928
241-AN-102	0	134	936
241-AN-103	0	459	501
241-AN-104	0	445	610
241-AN-105	0	538	588
241-AN-106	29	17	845
241-AN-107	0	230	871

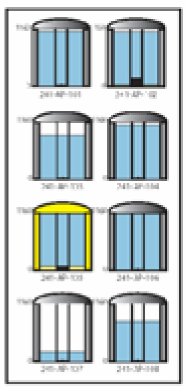


B-Tank Farm- 1943-47
12 @ 530 Kgal Tank Capacity, Single-Shell
4 @ 55 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-B-101 ■	28	81	0
241-B-102	0	28	4
241-B-103 ■	1	55	0
241-B-104	309	65	0
241-B-105 ■	28	262	0
241-B-106	122	0	1
241-B-107 ■	86	75	0
241-B-108	27	65	0
241-B-109	50	75	0
241-B-110 ■	244	0	1
241-B-111 ■	241	0	1
241-B-112 ■	15	17	3
241-B-201 ■	29	0	0
241-B-202	28	0	0
241-B-203 ■	49	0	1
241-B-204 ■	48	0	1

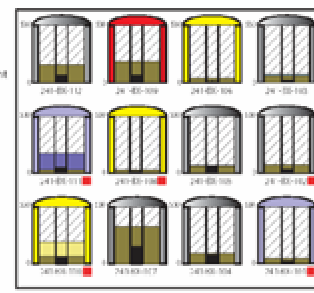
AP-Tank Farm- 1986
8 @ 1,160 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AP-101	0	0	1115
241-AP-102	23	0	1073
241-AP-103	0	0	893
241-AP-104	0	0	1099
241-AP-105	0	89	1050
241-AP-106	0	0	1135
241-AP-107	0	0	208
241-AP-108	0	0	815



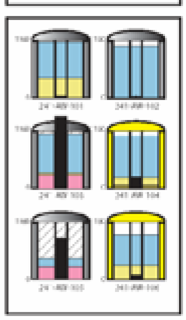
BX- Tank Farm- 1948-50
12 @ 530 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-BX-101 ■	48	0	0
241-BX-102 ■	79	0	0
241-BX-103	62	0	12
241-BX-104	97	0	3
241-BX-105	67	0	5
241-BX-106	38	0	0
241-BX-107	347	0	0
241-BX-108 ■	31	0	0
241-BX-109	193	0	0
241-BX-110 ■	65	139	1
241-BX-111 ■	32	157	0
241-BX-112	163	0	1



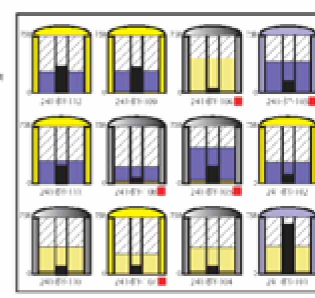
AW-Tank Farm- 1980
6 @ 1,160 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AW-101	0	396	732
241-AW-102	7	0	1032
241-AW-103	273	40	786
241-AW-104	66	157	851
241-AW-105	263	0	157
241-AW-106	0	283	618



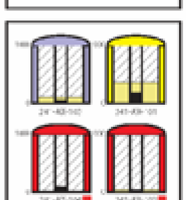
BY-Tank Farm- 1950-51
12 @ 758 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-BY-101	37	333	0
241-BY-102	0	279	0
241-BY-103 ■	0	408	0
241-BY-104	45	313	0
241-BY-105 ■	48	433	0
241-BY-106 ■	32	430	0
241-BY-107 ■	16	256	0
241-BY-108 ■	40	182	0
241-BY-109	24	263	0
241-BY-110	43	323	0
241-BY-111	0	301	0
241-BY-112	2	284	0



AX-Tank Farm- 1965-66
4 @ 1,000 Kgal Tank Capacity, Single-Shell

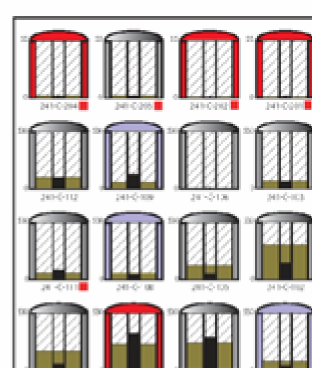
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AX-101	3	355	0
241-AX-102 ■	6	24	0
241-AX-103	8	99	0
241-AX-104 ■	7	0	0



C-Tank Farm- 1946-53
12 @ 530 Kgal Tank Capacity, Single-Shell
4 @ 55 Kgal Tank Capacity, Single-Shell

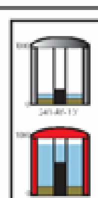
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-C-101 ■	88	0	0
241-C-102	316	0	0
241-C-103	71	0	1
241-C-104	259	0	0
241-C-105	132	0	0
241-C-106	3	0	0
241-C-107	247	0	0
241-C-108	66	0	0
241-C-109	63	0	0
241-C-110 ■	177	0	1
241-C-111 ■	57	0	0
241-C-112	104	0	0
241-C-201 ■	1	0	0
241-C-202 ■	0*	0	0
241-C-203 ■	1	0	0
241-C-204 ■	2	0	0

* (Less than 500 gallons)



AY-Tank Farm- 1971-76
2 @ 1,000 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AY-101	96	0	84
241-AY-102	151	0	741



LEGEND

- Saltcake or Supernatant to Supplemental Treatment
- Contact Handled TRU Sludge
- Remote Handled TRU Sludge
- Sludge to Waste Treatment Plant
- Saltcake to Waste Treatment Plant
- Supernatant to Waste Treatment Plant
- Available Space
- Restricted Space
- ■ Assumed/Confirmed Leaker

Tank Shell Color (Limiting Component): Al_2O_3, Fe_2O_3, Na_2O, P_2O_5, SO_3

Tank volumes updated as of 12/31/04

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